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X-point radiation and detachment control at ASDEX Upgrade

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Future fusion reactors require a safe, steady state divertor operation. In the detached regime, the power and particle fluxes to the divertor targets are sufficiently reduced to meet the material limits. In H-mode operation at the full-tungsten ASDEX Upgrade tokamak (AUG), this is achieved by injection of significant amounts of nitrogen into the divertor volume. This increases dominantly the divertor radiation and radiated power fractions of up to 90% were achieved at high heating powers (Pheat/R=12-13 MW/m).
In these conditions, the divertor is fully detached and the dominant radiation is emitted from a small, poloidally localized volume in the vicinity of the X-point. This X-point radiation is observed to vary its location relative to the X-point depending on seeding and power levels. Unlike the typical observation of such radiation at the X-point, identified as a MARFE, the scenario is stable and persisted against variation in heating power or seeding. The radiator is observed to move up to 15 cm inside the confined region, which corresponds to a normalized poloidal flux of ϱpol≈0.985. A further movement finally leads to a disruption of the plasma. The accessibility and implications of such a regime will be discussed in the view of future devices like ITER and DEMO.
The stability of the X-point radiator and the dependence of its position to external parameters such as N seeding level and heating power allow an active control of this scenario. This will allow the real-time control of a fully detached divertor, where target measurements are not sufficient any more. The sensor of the control is based on an array of horizontal channels of AXUV diodes, detecting the vertical position of the radiator. Similar to the existing controller on the divertor temperature [1], the nitrogen seeding level is used as actuator. The performance of this controller will be presented and compared to the existing controller for the divertor temperature at AUG and control schemes applied at other devices, such as DIII-D [2] and TCV [3].
[1] A Kallenbach et al 2010 Plasma Phys. Control. Fusion 52 055002
[2] D. Eldon et al 2017 Nucl. Fusion 57 066039
[3] T. Ravensbergen et al 2019 Submitted to Nuclear Fusion

Country or International Organization

Germany

Author: Dr BERNERT, Matthias (Max Planck Institute for Plasma Physics)

Co-authors: Dr REIMOLD, Felix (Max-Planck-Institute for Plasma Physics); KALLENBACH, Arne (Max--Planck-Institut f. Plasmaphysik); WISCHMEIER, Marco (Max Planck Institute for Plasma Physics); JANKY, Filip; SIEGLIN, Bernhard (Max-Planck-Institut for Plasma Physics); KUDLACEK, Ondrej (Max-Planck Institute of Plasma Physics); Dr TREUTTER, Wolfgang (MPG-IPP); Dr BRIDA, Dominik (IPP Garching); FÉVRIER, Olivier (Ecole Polytechnique Fédérale de Lausanne (EPFL)); HENDERSON, Stuart (UKAEA); KOMM, Michael (Institute of Plasma Physics of the Czech Academy of Sciences)

Presenter: Dr BERNERT, Matthias (Max Planck Institute for Plasma Physics)

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