Contribution ID: **31** Type: **Oral (Plenary Session)**

The Island Divertor Concept of the Wendelstein 7 Stellarator Line –Concept, Experimental Experience and Up-scaling to Reactor Relevant Size

Tuesday 5 November 2019 11:10 (20 minutes)

The island divertor (ID) concept investigated experimentally in the Wendelstein 7-AS (W7-AS) and the superconducting Wendelstein 7–X (W7-X) stellarator devices have so far proven to be extremely successful, and shown a favourable tendency towards improved detachment performance from W7-AS to W7-X. Stable detachment, which could be achieved only partially in W7-AS and required additional resonant magnetic perturbation (RMP) fields, is more easily accessible in W7-X without the necessary need of external RMP fields. The W7-X detachment is usually more complete in the sense that the target heat load reduces quite homogeneously without leaving noticeable hotspots, unlike in W7-AS. In the last W7-X experimental campaign, a 5.5 MW ECR-heated high line integrated density (1.1 E20 m-2) plasma was stably maintained under completely detached conditions over 26 s without any signs of impurity accumulation (constant Zeff = 1.5). An order of magnitude reduction of the peak heat loads was observed on the target plates monitored by IR-cameras without any indications for remaining hotspots. The sub-divertor neutral pressures were sufficient to pump towards the end of the discharge just about as much as was fuelled. This was achieved in an uncooled test divertor, which is presently being replaced by a fully actively cooled High Heat Flux (HHF) divertor of identical shape, aiming at 30 min 10 MW ECR-heated plasma operation.

The ID concept utilises the inherent resonant radial magnetic field components of the 3D shaped coils of these devices, which create magnetic islands at the edge. The edge islands provide a natural separatrix configuration. These structures are intersected by 3D shaped target plates suitably adapted to the basic geometry and symmetry of the magnetic field configurations. The small field line pitch, i.e. the internal rotational transform around the island centre, leads to long connection lengths Lc (several 100 m) and thereby increases the relative weight of perpendicular transport. Besides Lc, the radial island width Wi is another important geometric parameter for the ID, which has been evidenced in W7-AS experiments. By making use of the in-vessel control coils and the external planar coils, it is possible to vary Wi and Lc independently from each other and to optimize the ID performance with respect to particle and power exhaust as well as impurity retention.

EMC3-Eirene simulations suggest that the, compared to W7-AS 2x larger islands, favouring access to high recycling conditions, and the more symmetric, drift optimised flux surface geometry are the main reasons for the improved detachment performance of W7-X. Indeed 2.5 times the separatrix density (5.5 E19 m-3) has been spectroscopically measured near the divertor target plates (1.3 E20 m-3) just before the transition into detachment. Based on the W7-AS and W7–X results, an estimate of the basic ID behaviour has been made for a device up-scaled from W7-X to a reactor scale device. This paper summarizes the main results obtained so far from W7-AS and W7-X and provides a brief physical interpretation of the leading effects and a rough assessment of their relevance to a reactor.

Country or International Organization

Germany

Authors: Dr KOENIG, Ralf (Max Planck Institute for Plasma Physics); Dr FENG, Yuehe (Max-Planck-Institut for Plasma Physics); JAKUBOWSKI, Marcin (Max Planck Institute for Plasma Physics); Dr KRYCHOWIAK, Maciej (Max-Planck-Institute for Plasma Physics); SCHMITZ, Oliver (University of Wisconsin - Madison, Department of Engineering Physics); Dr EFFENBERG, Florian (Department of Engineering Physics, University of Wisconsin - Madison); Dr REIMOLD, Felix (Max-Planck-Institute for Plasma Physics); Dr ENDLER, Micheal (Max-Planck-Institute for Plasma Physics); Dr OTTE, Matthias (Max-Planck-Institute for Plasma Physics)

Presenter: Dr KOENIG, Ralf (Max Planck Institute for Plasma Physics)

Session Classification: Stellarators Divertors

Track Classification: Divertor and Confinement