Contribution ID: **94** Type: **Poster**

Diagnostic set-up and modelling for investigation of synergy between 3D edge physics and plasma-wall interactions on Wendelstein 7-X

Thursday, 20 October 2016 08:30 (4 hours)

Plasma–wall interaction (PWI) in the divertor region of Wendelstein 7-X (W7-X) will be of great importance for operational phase OP1.2. While the erosion of the divertor will have an impact on its lifetime and is therefore a critical subject of investigation, fundamental PWI studies in the divertor region are in many ways equally significant. These plasma–wall interactions will be influenced by impurity transport, where the complex 3D magnetic geometry will play a crucial role, but this magnetic geometry could itself be influenced by plasma effects such as Pfirsch–Schlüter and bootstrap currents. Therefore, along with measurements of obvious quantities such as heat flux, PWI research in the divertor region will also require measurements of the temperature in the plasma edge and of the concentration and distribution of different impurities, in combination with modelling of impurity transport. In order to investigate systematically the synergy between 3D edge physics and PWI, a set of edge diagnostics has been developed for the upcoming W7-X experiments and the EMC3-EIRENE code is being extended to helium plasmas for OP1.1.
A set of endoscopes has been designed for visible and ultraviolet spectroscopy and tomography of the plasma edge, along with infrared thermography of the divertor tiles. Two-dimensional profiles of impurities (e.g. He, C) will be measured by two endoscopes viewing the island divertor region in the plasma edge with a spatial resolution of <2mm. A multipurpose manipulator, which is used as the carrier either of the probe head for measuring the plasma edge profiles or of samples for plasma exposure studies, was installed at the outside mid-plane on W7-X in 2015. A poloidal correlation reflectometer has also been installed. This system consists of an antenna array observing the propagation of turbulent phenomena in the mid-plane. The EMC3-EIRENE code package has been extended for plasma edge transport in helium plasma at Wendelstein 7-X using a hybrid fluid–kinetic approach by enabling EMC3 to treat non-hydrogen isotopes and extending the usage of EIRENE features within EMC3-EIRENE.
In this paper, a detailed physics concept of the diagnostic set-up and modelling for investigation of synergy between 3D edge physics and plasma–wall interactions will be presented.

Paper Number

EX/P5-10

Country or International Organization

Germany

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Session Classification: Poster 5

Track Classification: EXD - Magnetic Confinement Experiments: Plasma–material interactions; divertors; limiters; scrape-off layer (SOL)