Dynamics and transport in the W7-X Scrape-Off-Layer measured by reciprocating probes

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Wendelstein 7-X (W7-X) is an optimised stellarator employing an island divertor. In this concept, large, low rational magnetic islands form the three-dimensional heat and particle exhaust to the divertor. Understanding the plasma properties and dynamics especially within the islands is essential for the assessment of parallel and perpendicular heat and particle transport in the edge of W7-X and therefore crucial for both sustaining high performance plasmas as well as ensuring safe divertor operation.

One major and established diagnostic approach for Scrape-Off-Layer (SOL) measurements is the use of reciprocating probes. At W7-X, a versatile carrier system for probe heads, the Multi-Purpose Manipulator (MPM), is installed at the outboard mid-plane. From the plasma vessel wall, it can perform fast plunges through the SOL (including the island chain) up to the last closed flux surface. Using the MPM with a dedicated probe head for fluctuation studies containing a poloidal array of 22 Langmuir pins and a Mach probe for parallel and perpendicular flows, we obtained radial profiles of plasma density, electron temperature, plasma flows and electric fields. These measurements allow us to infer properties relevant for divertor operation, such as the plasma pressure driving the parallel flow to the divertors or the SOL width which is defined by the ratio of parallel and perpendicular transport and is related to the strike line properties on the divertor. Exploiting in addition the poloidal probe array gives insight into the poloidal dynamics and propagation of turbulent fluctuations in plasma density and poloidal electric field and the associated perpendicular fluctuation-induced transport.

A particular focus of this contribution is on the peculiarities of the island divertor concept. First data analysis from the 2017 operation phase OP1.2a suggests a high sensitivity of plasma parameters in the islands (e.g. density, temperature, flow, electric field) to subtle changes in the edge magnetic field topology. Typical plasma parameters obtained using the MPM are electron temperatures up to 100 eV, densities up to $1 \cdot 10^{19}$ m^{-3} and electric fields up to 20 kV/m. The dependency of SOL plasma profiles and the associated gradient-driven turbulent transport is observed to display a strong scaling with central heating power and core plasma density.