Filamentary transport in the Wendelstein 7-X Scrape-off Layer

C. Killer[a], O. Grulke[a,b], B. Shanahan[a], M. Endler[a], K. Hammond[c], L. Rudischhauser[a], the W7-X Team[a]

[a] *Max Planck Insitute for Plasma Physics, Greifswald, Germany*
[b] *Department of Physics, Technical University of Denmark, Lyngby, Denmark*
[c] *Princeton Plasma Physics Laboratory, Princeton, NJ, USA*

carsten.killer@ipp.mpg.de

In tokamaks, blob-filaments have been shown to significantly contribute to the perpendicular transport in the Scrape-Off Layer (SOL) due to their coherent radial propagation, thereby impacting key SOL characteristics as, e.g., SOL width, plasma recycling at the first wall and high intermittent heat loads on plasma facing components (PFC). In stellarators, the propagation behavior of turbulent filaments is much less clear. The aim of the optimized stellarator Wendelstein 7-X (W7-X) is to demonstrate the viability of stellarators for future power plant. To control the plasma exhaust, W7-X employs an island divertor, where the SOL is formed by a chain of large intrinsic magnetic islands which are intersected by the modular divertor target plates. In this presentation, experimental results on blob dynamics in W7-X based on reciprocating and target Langmuir probes are presented. Blobs are identified via conditional averaging of poloidally distributed electric probes on a radially reciprocating probe head, measuring plasma density and potential fluctuations. Similar to the situation in tokamaks, the measurements clearly yield a dipolar potential distribution associated with large density fluctuations and a resulting radial ExB drift. Exploiting the direct magnetic connection between reciprocating probes and divertor probes reveals that the blobs form filaments over large distances parallel to the magnetic field lines, extending to the divertor. The parallel dynamics inside the filaments are very fast, on the electron thermal velocity time scale. The role of plasma conditions and local magnetic topology for blob properties is discussed and their propagation velocities are compared to typical scaling laws. So far, blobs in W7-X are found to be in the sheath connected regime even though the connection lengths in the W7-X SOL are rather long (~100m). The radial velocity of blobs is much smaller than in tokamaks with comparable plasma conditions. The experimental results are accompanied by dedicated simulations of seeded filaments in the actual three-dimensional W7-X magnetic geometry, which yield a good quantitative agreement. The modeling suggests that the blob velocity is determined by the average curvature along a field line. In particular, the slow radial velocity of blobs in W7-X is due to the comparably small magnetic curvature. As a consequence of their slow radial propagation, blobs do not perform significant radial movement during their life-time. Combining this observation with their ubiquitous occurrence in the probed region of the SOL implies that the turbulence is local, i.e. the blobs are born, measured, and decay on the same flux surface. This interpretation is supported by rather flat skewness and kurtosis profiles in the SOL. Therefore, radial filament propagation plays only a minor role for perpendicular transport in the W7-X SOL. In particular, intermittent heat loads to PFCs due to ballistically propagating filaments are not observed.