Characterisation of power flux reduction in the Wendelstein 7-X divertor plasma with Langmuir probes

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During the first divertor operation phase (OP1.2a) of the stellarator Wendelstein 7-X strong reductions in heat load by a factor of five or more on the graphite divertor targets were observed for periods of time within numerous discharges. During these we recorded substantial drops in temperature by an order of magnitude to below 6 eV and increases in density with the 40 Langmuir probes embedded in the divertor. The probe results support the ongoing discussion on this power detachment [1] with measurements over a range of poloidal distances, sampling the magnetic island divertor field inside the island, in the strike line and in the private flux region.

Design, capabilities and limitations of the Langmuir diagnostic as well as the data analysis model are briefly introduced. The Langmuir probe data are compared with observations of other relevant diagnostics such as the infrared and spectroscopic observation systems, and the thermal helium beam diagnostic [2, 3, 4]. In addition to discussing the indications for detachment in detail we characterise the general behaviour of the divertor plasma under different global plasma conditions and present evidence of up-down asymmetry and active scrape-off layer cooling by impurity seeding and edge fuelling.

[1] D. Zhang et al., First observation of a stable highly-radiative divertor regime at stellerator W7-X, EPS 2018, to be published

[2] M.W. Jakubowski et al., Infrared Imaging Systems for wall protection in the W7-X stellarator, HTPD 2018, to be published

[3] M. Krychowiak et al., Overview of diagnostic performance and results for the first operation Phase in Wendelstein 7-X, RSI 87, 2016

[4] T. Barbui et al., Feasibility of line-ratio spectroscopy on helium and neon as edge diagnostic tool for Wendelstein 7-X, RSI 87, 2016