Impurity flow measurements with Coherence Imaging Spectroscopy at Wendelstein 7-X

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An experimental investigation of particle parallel flows has been carried out at Wendelstein 7-X (W7-X), the most advanced stellarator in the world. The studies are restricted to the scrape-off layer (SOL) plasma region, based on the island divertor exhaust concept. The aim of the measurements is to set the basis for a physics analysis of the SOL dynamics by obtaining direct information on convective heat transport, by assessing the predominant flow directions of the main plasma ions and of fusion-products or wall-released impurities. In this way, a better comprehension of the interplay between the transport parallel and perpendicular to the SOL field lines can be achieved, contributing to the understanding of the effectiveness of the island divertor configuration.

The chosen instrument for the experimental studies is the Coherence Imaging Spectroscopy (CIS) diagnostic, a camera-based interferometer capable of measuring 2D Doppler particle flows associated with a selected visible line from the plasma [1]. The diagnostic is distinguished by its high time resolution and spatial coverage, allowing the visualization and measurements of flow velocities for a full module of W7-X simultaneously. A CIS diagnostic has been fully designed for W7-X with an improved level of accuracy achieved thanks to the implementation of a new calibration source, a continuous-wave-emission tunable laser. The laser allowed a full characterization of the diagnostic and a frequent precise calibration, making the CIS system reliable for parallel flow investigations during the operational campaign OP1.2 [2]. The CIS application led to the first detection of the 3D counter-streaming flow pattern of the W7-X SOL [3]. The importance of the CIS measurements have been further confirmed with dedicated simulations of the SOL plasma parameters by the EMC3-EIRENE code [2], and their validity checked by comparison to other edge diagnostics [2, 4]. The CIS results show the effects related to dynamical changes in the SOL due to impurity gas puffs or the development of a plasma current [4, 5]. Moreover, CIS can be used as a powerful tool to test the limits of the current theoretical models, for example in the case of forward and reversed field experiments [3, 6].

References

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