17th Kudowa Summer School "Towards Fusion Energy" Kudowa Zdrój, 3 – 7 June, 2024

Impurity Spectroscopy in Wendelstein 7-X: From Measurement to Transport Investigations

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Abstract

In a fusion plasma, the presence of plasma impurities (i.e., all species not used as fuel) can be detrimental to the plasma performance. While impurities generally dilute the fuel and thus reduce the fusion efficiency, their line radiation in the boundary plasma is an important dissipation channel for power exhaust. An unfavorable radial distribution of the radiative losses however, combined with excessive radiation, is a critical loss channel for the plasma energy and can even lead to a radiative collapse of the plasma. In a stellarator with its inherent tendency to accumulate impurities in the plasma core due to unfavorable neoclassical transport in the ion root regime, understanding the relevant transport mechanisms is therefore a crucial task on the path to high performance plasmas and radiation control.

Amongst the non-invasive diagnostics, spectroscopy is one of the main tools to investigate the impurity composition and their transport behavior in fusion plasmas. After an overview on theoretically predicted impurity transport mechanisms and models, both with a focus on their stellarator specific peculiarities, relevant spectroscopic diagnostics dedicated to impurity studies at the stellarator Wendelstein 7-X will be presented. Following an introduction to the methods used to evaluate the experimental data, an overview on recent findings concerning the transport and potential control of impurities in Wendelstein 7-X will be given.