3-D Modeling of Edge Transport and Plasma Surface Interactions for Wendelstein 7-X Startup Plasmas

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The quasi-isodynamic stellarator Wendelstein 7-X finished recently its first plasma operation. The initial standard field configuration consisted of closed magnetic flux surfaces avoiding magnetic islands in the plasma boundary [1],[2]. The scrape-off layer (SOL) was defined by five distinct limiters enabling unique studies of aspects of 3-D plasma edge transport and plasma surface interaction (PSI). This contribution focuses on the numerical investigation with the 3-D fluid plasma edge and kinetic neutral transport code EMC3-Eirene and a first comparison with some experimental results. It is shown that the 3-D SOL consists of three separate helical magnetic flux bundles of different field line connection lengths L_C. It is found that the plasma edge transport is strongly correlated with L_C. Parameter scans are performed revealing e.g. a drop of limiter peak heat fluxes from 12 MWm^{-2} down to 7.5 MWm^{-2} and an increase of the heat flux channel widths $\lambda_{q||}$ by a factor of two with raising the density from $1{\cdot}10^{18}\mathrm{m}^{-3}$ to $1.9{\cdot}10^{19}\mathrm{m}^{-3}$. Initial analysis of IR camera observation data confirms the correlation between deposited heat flux and topology. Finally, an iota scan was performed which causes a change of the edge distribution of the L_C with signicant impact on the PSI according to EMC3-Eirene predictions. The heat load pattern is rather sensitive to iota changes and shows clear distinction between flux bundles of different connection lengths.

[1] S. Bozhenkov, F. Effenberg, et al. Limiter for the early operation phase of W7-X. 41st EPS Conference on Plasma Physics (2014).

[2] T. Sunn Pedersen et al. Plans for first plasma operation of Wendelstein 7-X. Nuclear Fusion, 55, 12, 126001-126013 (2015)

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