Neoclassical transport in the High density H-mode in Wendelstein 7-AS – revisited with new tools

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In view of the aim for long-pulse operation of Wendelstein 7-X, it is important to understand under which circumstances one can expect to avoid impurity accumulation. Unless the impurity sources at the edge were kept small in Wendelstein 7-AS (W7-AS) normal confinement (NC) plasmas, impurities often accumulated in the centre which resulted in a radiation collapse that terminated the discharge [1]. However, this was avoided in so-called high-density H-mode (HDH) plasmas, which were NBI heated and characterised by a density exceeding a certain heating-power-dependent threshold ($1.5 - 2.1 \cdot 10^{20}\mathrm{m}^{-3}$). The transport in the HDH regime was analysed in Ref. [2], but the experimentally observed efficient flush-out of impurities could not be explained by neoclassical transport, and there was no definite experimental evidence for turbulent mode activity at the plasma edge. Recently, analytical work [3, 4] has shown that when the impurities are in the highly collisional Pfirsch-Schlüter regime and the main ions in the long mean free path regime, neoclassical "temperature screening" (outward flux of impurities driven by the temperature gradient) can prevent accumulation in stellarators, even when the radial electric field points inwards. To include this effect in a numerical analysis of the neoclassical impurity transport in the W7-AS HDH mode, one needs a more detailed physics model than was used in previous investigations. In this work, we therefore use the SFINCS code [5, 6], which enables us to include the full linearised Fokker-Planck collision operator as well as the variation of the electrostatic potential on the flux surface. The SFINCS results are compared with results from the DKES code [7], which employs a pitch-angle scattering collision operator.

References

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