Investigations of the role of neoclassical transport in ion-root plasmas on W7-X


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The role of the radial electric field in high performance ion-root plasmas on Wendelstein 7-X (W7-X) is examined and compared with neoclassical predictions. The W7-X stellator is the world’s first large scale optimized stellarator. One of the important targets chosen for optimization during the W7-X design process was the reduction of core neoclassical heat transport. This optimization was targeted for reactor relevant high-density plasmas with $T_e \approx T_i$ in which the neoclassical ambipolar radial electric field is expected to negative throughout the plasmas core.

Measurements of the core radial electric field ($E_r$) have confirmed that ion-root conditions (negative $E_r$ in the plasma core) have been achieved in W7-X with high-density plasmas and central ECRH. These measured $E_r$ profiles agree well with the neoclassical ambipolar $E_r$ predicted by the code SFINCS. This good agreement provides confidence in the validity of neoclassical calculations in high-density ion-root conditions, and enables initial studies on the role of neoclassical transport in the optimized high-density regime of W7-X.

Profile measurements of electron temperature ($T_e$), ion temperature ($T_i$) and electron density ($n_e$) along with approximations for the average value of $Z_{eff}$ have been used as inputs to the SFINCS code to calculate the ambipolar $E_r$ profile along with neoclassical ion and electron heat flux profiles ($Q_{NI}, Q_{NCe}$). Finally the total experimental energy input to the plasma from ECRH heating has been compared to the neoclassical heat fluxes to provide a first estimate for the fraction of transport that can be attributed to neoclassical processes in reactor relevant high-density ion-root conditions.