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 stellarator 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 Er in the plasma core) have been achieved in W7-X with high-density plasmas and central ERCH. These measured Er profiles agree well with the neoclassical ambipolar Er 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_{NCi}, 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.