Neoclassical transport and flows in pedestals with impurities

I. Pusztai\textsuperscript{1}, S. Buller\textsuperscript{1}, M. Landreman\textsuperscript{2}, S. L. Newton\textsuperscript{1,3}

\textsuperscript{1}Department of Applied Physics, Chalmers University of Technology, SE 412 96 Göteborg, Sweden
\textsuperscript{2}IREAP, University of Maryland, College Park, MD 20742, USA
\textsuperscript{3}CCFE, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK

Corresponding author: Name: Istvan Pusztai Email: pusztai@chalmers.se

Edge transport barriers are of crucial importance for the viability of the tokamak concept in becoming an energy source. However, the change from carbon to metallic plasma facing components (PFCs) in major fusion devices was accompanied by a reduction in the pedestal performance (JET \cite{1,2}, ASDEX \cite{2}). Performance representative of carbon PFC operation could in some cases be recovered using impurity seeding, pointing to a possible impact of impurities on pedestal confinement.

We investigate the effect of non-trace impurities – in particular, nitrogen – on collisional transport and flows in a sharp density pedestal (characterized by an ion orbit width scale density variation and subsonic flows), using the global, $\delta f$, Eulerian neoclassical solver PERFECT \cite{3}. We show that the steady state collisional fluxes are significantly altered by the presence of the sharp density pedestal: most notably, the coupling between different flux-surfaces allows for non-ambipolar particle fluxes and non-zero transport of toroidal momentum. We find the toroidal angular momentum transport – dominated by the main ions – to be significantly increased in magnitude by going from trace to non-trace impurity content. Unlike the core, in the sharp gradient region the friction of ions on electrons can compete with that on impurities, leading to ion and impurity particle fluxes in the same direction even at non-trace impurity concentrations.

Due to the relevance for burning plasmas and diagnostics, we dedicate a separate discussion to the radial transport of helium impurities, and compare their toroidal and poloidal flows to those of the main species.

\begin{thebibliography}{9}
\bibitem{1} F. Romanelli et al., Nuclear Fusion \textbf{53}, 104002 (2013).
\end{thebibliography}