Detachment onset in MAST-U according to SOLPS-ITER

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The forthcoming MAST-U tokamak will assess the efficacy of the Super-X divertor in reducing the upstream collisionality at which target detachment occurs. This will be the first experimental test of the Super-X on a spherical tokamak and will begin to answer whether this method of power exhaust can be realised in a reactor-scale machine. Previous edge plasma simulations by [Havlíčková et al. 2014] using the SOLPS code predicted that the Super-X configuration on MAST-U will reduce the required upstream density for detachment onset by a factor ~3 relative to the conventional configuration. However, the details of the physics driving detachment onset in MAST-U SOLPS simulations has not been investigated until now.

Here we assess – by means of particle, pressure and heat balance routines – the physics responsible for a rollover in the target ion flux (a key signature of detachment onset) as the upstream plasma density is increased in SOLPS-ITER simulations. These newly-developed post-processing routines produce similar plots to those shown previously by [Kotov and Reiter 2009]. Importantly, however, they now include the sources from interactions between the plasma and D atoms, D₂ molecules and D₂⁺ ions, allowing us to assess the relative importance of various neutral-plasma reactions in dissipating total pressure and heat.

A key result of our work is that elastic collisions with D₂ molecules are found to be the primary mechanism by which the total pressure at the divertor entrance is dissipated by neutrals. This dissipation of total pressure, which occurs after the heat has been dissipated (primarily by radiation), is essential for the target ion flux rollover to take place. We use the two-point model formulation equations [Stangeby et al. 2015] to understand how the various heat and pressure loss mechanisms affect a rollover in the target density. We will also assess the role of intrinsic carbon impurities in this process.

References

Havlíčková E et al. 2014 Contrib. Plasma Phys. 54 449

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