

P2.1020 Ion orbit losses in a radially resolved model of the H-mode barrier

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The radial electric field E_r is thought to play a role in the suppression of turbulence in the edge transport barrier that causes H-mode confinement in tokamaks. A range of mechanisms have been proposed that may positively or negatively contribute to E_r . Among the non-ambipolar particle transport channels that together determine the electric field, two processes are particularly localized near the last closed flux surface (LCFS) and may be dominant there: charge exchange friction of the plasma ions with incoming neutral atoms can reduce plasma rotation (i.e. weaken E_r), whereas ion orbit losses can strengthen E_r . The latter process is due to magnetically confined particles near the LCFS scattering into orbits that leave the plasma. In a single-null divertor configuration, the dominant channel is pitch-angle scattering into banana-type orbits that pass to the divertor-side of the x-point. This loss process generates a radial electric field because it is much stronger for ions than for electrons, due to the ions' larger banana orbit widths.

The proper calculation of this ion flux requires solving the Fokker-Planck equation for the ion distribution in (at least) the pitch angle and radial coordinate [1]. While pitch-angle scattering is essential for the loss process, further collisions on the loss orbit have the opposite effect of reducing the charge separation. In all, the process is very sensitive to the ions' velocity and radial position due to the strong gradient in loss orbit lengths and collisionalities.

In order to predict the H-mode barrier width, but also to model L-H transition dynamics, the total orbit loss flux across the LCFS, as given e.g. in [1] does not suffice. One needs a radially resolved ion flux, for which ad-hoc expressions have been given in e.g. [2, 3]. The present paper derives a different expression for the radially resolved flux from first principles. This flux is a function of the radial coordinate, the pitch angle scattering frequency, loss-orbit collisionality, and the radial electric field. It is demonstrated that all these dependencies are needed simultaneously if used in a model that determines the radial profile of E_r across L-H bifurcations and bifurcations of the hysteresis PLH - PHL (the difference between the threshold heating powers for L-H and H-L transitions).[4]

References

[1] K.C. Shaing, Phys. Fluids B 4, 3310 (1992) [2] S. Toda et al., Plasma Phys. Contr. Fusion 39, 301 (1997) [3] T. Kobayashi et al., Nature Scient. Rep. 6, 30720 (2016), DOI: 10.1038/srep30720 [4] H.J. de Blank et al., Physica D 331, 13 (2016)

Presenter: DE BLANK, H. (EPS 2019)

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