Dynamics of the onset and removal of an edge transport barrier in non-linear plasma edge simulations

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Transport barriers are a common feature in magnetic fusion devices. By quenching locally the turbulence, they provide a noticeable improvement of the energy confinement. The H-mode regime is characterised by the presence of an external transport barrier (ETB) and used by the reference ITER scenario. Since its discovery, the H-mode has been the subject of extensive studies, however theoretical understanding of the phenomenon remains unresolved [1]. This causes significant uncertainties on the value of the L-H transition power threshold [2]. Additionally, controlling the associated transient phenomena such as edge localised modes (ELMs) [3] or the intermediate phase (I-phase) [4] of the transition/back-transition is necessary to avoid anticipated degradation of the plasma facing components.

In our work, non-linear results of flux-driven resistive ballooning simulations of the plasma edge accounting for neoclassical force balance governing the poloidal flow show the spontaneous formation of a transport barrier above a certain threshold of input power [5]. The three-dimensional model describes the evolution of charge and energy balances in the confined plasma under the assumptions of large aspect ratio and constant density. Accounting for the radial and temporal variations of the neoclassical coefficients as functions of the pressure profile is shown to be a critical element allowing for qualitative features and characteristic dynamics of the L-H transition to bo recovered. In particular, crossing the threshold with a slow power ramp exhibits rich interplay between turbulence, turbulence-generated flows and the mean flow due to neoclassical friction, resulting in a dithering of the radial electric field.

References

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