A new model of the L–H transition and H-mode power threshold

In order to understand the mechanism of the confinement bifurcation and H-mode power threshold in magnetically confined plasma, a new dynamical model of the L–H transition based on edge instability phase transition (EIPT) has been developed. With the typical plasma parameters of the EAST tokamak, the self-consistent turbulence growth rate is analyzed using the simplest case of pressure-driven ballooning-type instability, which indicates that the L–H transition can be caused by the stabilization of the edge instability through EIPT. The weak $E \times B$ flow shear in L-mode is able to increase the ion inertia of the electrostatic motion by increasing the radial wave number of the tilted turbulence structures, which play an important role for accelerating the trigger process of EIPT rather than directly to suppress the turbulent transport. With the acceleration mechanism of $E \times B$ flow shear, fast L–H and H–L transitions are demonstrated under the control of the input heating power. Due to the simplified scrape-off-layer boundary condition applied, the ratio between the heating powers at the H–L and L–H transition respectively differs from the ratio by Nusselt number. The results of the modeling reveal a scaling of the power threshold of the L–H transition, $P_{L-H} \propto n_0^{0.76}B_0^{0.8}$ for deuterium plasma. It is found finite Larmor radius induces an isotope effect of the H-mode power threshold.

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