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A 3D Nonlinear Simulation Study of the L→H Transition Criterion

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High confinement mode (H-mode) is essential as a baseline operating scenario in ITER. In order to develop a predictive model of the power threshold for access to H-mode in ITER, it is essential to understand first the underlying mechanism that triggers the transition. It is widely accepted that edge transport barrier (ETB) formation in H-mode is due to the suppression of turbulence by E x B flow shear. In several recent experiments, turbulence-driven flows were suggested as a trigger for the L→H transition. In this paper, a 3D fluid simulation model of the L→H transition is presented. Specifically, we report the results of 3D flux-driven simulations of resistive ballooning modes (RBM) turbulence with neoclassical flow damping effect in the edge of a tokamak. It is found that ETB forms naturally due to mean shear feedback through evolving pressure gradient once input power exceeds a threshold value. We show that (1) the transition to ETB is triggered by the turbulence-driven flow via a limit cycle oscillation (LCO) of turbulence intensity and E x B flow shear; (2) the correct transition criterion (threshold) is given by R_T > 1 (R_T: normalized Reynolds power defined as a ratio of the Reynolds power to the rate of energy input into the turbulence), instead of the conventional mean shear criterion, i.e., E x B flow shearing rate larger than linear growth rate; (3) neoclassical poloidal rotation damping effect significantly affects the transition process. A slow power ramp-down simulation is also performed to study H→L back transition and hysteresis phenomena. Detailed results will be presented.

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