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TH/P2-19: Evolution of Ion Heat Diffusivity and Toroidal Momentum Diffusivity during Spontaneous ITB Development in HL-2A

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Toroidal momentum torques generating V_t (toroidal flow) affect ITB evolution and decay in TFTR, JT-60U and DIII-D, suggesting that momentum inputs could offer a means for controlling barrier dynamics. An important question is whether it is possible to produce and control an ITB with inputting toroidal momentum in a discharge. To explore the role of external inputs of toroidal momentum on the development of ITBs we model the NBI heating discharges in HL-2A (R=1.64m, a=0.4m, B_t=2.8T, I_p=0.48MA) by using TRANSP. The modeled discharge: B_t=2.6T, I_p =300kA, line averaged density=2.4x10ˆ19/mˆ3, single null divertor, H-mode boundary. As many experiments showed that optimized q-profile is one of the essential ingredients in establishing ITB, 0.5MW LH power in the current drive mode is injected at t=0.8s to control the current profile. Since the 2.45 GHz LH wave drives off-axis current in HL-2A, the q-profile with weak shear region extended to x˜0.8, q_0>2.0 and q_a˜5.3 is established after the current profile sufficiently relaxed (at t˜1.1s). In order to control the toroidal momentum input, 3MW NBI (E=45keV) is injected tangentially with both co- and counter-injection during t=0.4-1.8s. The heat and momentum transport is calculated with a physics-based model GLF23. The transport model includes turbulence suppression mechanisms of EXB rotation shear. With appropriate neutral beam injection the nonlinear interplay between the transport determined gradients in V_t and T_i,e and the EXB flow shear (including q-profile) produces transport bifurcations, leading to a stepwise growing ITB. After its growth duration steady ITB is formed from t˜1.35s. The ITB establishment is dependent on the toroidal momentum input. Quasi-steady ITBs can not be established unless the co-injected NBI power is in the range of 2.85MW to 2.4MW (correspondingly the counter-injected power is 0.15MW to 0.6MW respectively), which suggests that the NBI producing toroidal flow plays an important role in the ITB formation. The relationship between viscosity and ion heat transport in the ITB formation process is studied. Detailed examination of the evolution of toroidal momentum diffusivity and ion heat diffusivity in a region around the ITB development shows that the transport barrier of momentum develops more quickly and its enhanced confinement region extends further outward than that of heat.

Country or International Organization of Primary Author

China

Collaboration (if applicable, e.g., International Tokamak Physics Activities)

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