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Recent progress of L-H transition physics and H-mode power threshold studies in EAST

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First L-H transition on EAST was found in its 2010 campaign [1]. Since then topics of L-H transition physics and H-mode power threshold are well investigated. Recently, progress of the bearing of intermedia phase (I-phase [2]) [3,4] and small amplitude oscillations (SAOs) [5] on L-H transition and conditions of divertor configuration [6,7] as well as ion ∇B drift direction [8] on H-mode power threshold are made. Primary one-dimension model of I-phase and H-mode power threshold is also proposed [9,10].

SAOs at a frequency of a few kilohertz are observed in normal L-modes and before the L-H transitions [5]. Under sufficient auxiliary heating, SAOs can transit to the H-mode or I-phase. In SAOs, the turbulence level preceding the radial electric field and floating potential perturbation about 90° in phase at the bottom of E_r well, which is consistent with the model of zonal-flows and turbulence interaction. Comparing the features of SAOs with I-phase we found that SAOs-phase remains in L-mode, while I-phase is more like a part of H-mode. The poloidal magnetic perturbations of SAOs and I-phase are poloidal in-out/up-down asymmetric and toroidal symmetric [3,5]. A fast L-H transition induced by sawtooth crash shows that the poloidal flow shear at the very plasma edge increases ~25% just before the L-H transition [11]. This suddenly risen poloidal flow shear is motivated by an edge heat flux peak originally released by a sawtooth crash at the plasma core. Associated with the critical poloidal flow shear, the local turbulent decorrelation rate increases significantly. The increased turbulent decorrelation rate compensated by nonlinear energy transfer rate from the turbulence to the low-frequency shear flows, exceeding the turbulence energy input rate, is sustained for several hundred microseconds till the turbulence quench happening.

As the increase of source heating power and the extension of operational density window, the low density dependence of the L-H power threshold, namely density roll-over dependence on H-mode power threshold, are identified in the Mo/C wall (molybdenum wall, graphite lower divertor and carbon upper/lower divertor) and metallic wall (molybdenum wall, graphite lower divertor and tungsten upper divertor) on EAST [6,7]. With single null configuration the H-mode power threshold has a clear dependence of toroidal field direction (clockwise or counterclockwise). A factor of 2-3 increase in $P_{\mathrm{L\text{-}H}}$ is observed for the ion ∇B drift away from the primary X-point, although edge and core impurities quantified by spectroscopy measurements are in comparable levels [8]. Besides, correlation analysis of H-mode power threshold and divertor geometry in scanning X-point is summarized. Outer leg length (distance from X-point to outer strike point) has the highest correlation coefficient with H-mode power threshold, which explains the data scattering within the same plasma parameters [7]. Lithium conditioning on every operational morning reducing the H-mode threshold power is also observed when the lithium accumulation is up to 0.8 kilograms.

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