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Recent advances in EAST physics experiments towards high-performance steady-state H-mode operation

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The research programme of Experimental Advanced Superconducting Tokamak (EAST) aims for demonstrating steady-state advanced high-performance H-mode plasmas and understanding its underlying physics with ITER-relevant magnetic configuration, plasma control and heating schemes. Recently, two major EAST experimental research headlines, *i*) the development of steady-state scenario and *ii*) the exploration of physics and control of plasma transport and the major MHD instabilities, have been orientated towards the high β_P regime with more ITER-relevant condition, such as a low torque injection, RF-dominated heating and current drive, and an ITER-like tungsten divertor with the monoblock technology. Several significant new progresses of EAST physics experiments have been achieved.

The first demonstration of > 50 s long-pulse fully non-inductive steady-state H-mode plasma, sustained only by RF heating and current drive, has been achieved with a good plasma confinement ($H_{98(y2)} \sim 1.1$) and $\beta_P \sim 1.1$ [2, 3]. A good impurity and particle fluxes control has been observed by applying on-axis ECRH and further assisted by appearing of an edge coherent mode (ECM) at the plasma edge over the H-mode phase. Splitting of striking point on the outer divertor footprint has been seen, it can effectively reduce the peak heat load on the divertor plate. TRANSP power balance analysis shows that a significant reduction of the effective electron thermal diffusivity by an order of magnitude occurs at a large plasma minor radius, $\rho \sim 0.4 - 0.7$. This result indicates that the improved core confinement with internal transport barrier (ITB) feature can be sustained for tens of seconds. A stationary current density profile, which was maintained fully by effective RF heating and CD, has been observed in this long-pulse discharge. This suggests a possible method of active controlling plasma profile/transport by optimizing RF power deposition in EAST.

A new small/no ELM H-mode regime associated with a low-*n* (mostly $n = 1$ and sometimes $n = 2$) electro-Magnetic Coherent Mode (MCM) at 30-60 kHz as the dominant mode in the pedestal region has been obtained in a moderate pedestal collisionality regime ($\nu_e^* < 0.5$) with a good energy confinement, $H_{98(y,2)} \gtrsim 1.1$ [4]. This small/no ELM H-mode regime with MCM appears to be more attractive than that with ECM, since the latter is only obtained at relatively higher pedestal collisionality regime ($\nu_e^* \gtrsim 1$).

Complete ELM suppression using low *n* RMP in low rotating H-mode plasma with RF heating has been achieved on EAST [5]. During the transition between ELM mitigation and suppression, a clear nonlinear variation of the plasma response to low *n* RMP was observed for the first time.

On EAST, several methods, including *i*) change of edge magnetic topology by the application of either LHWs [7] or RMPs [5], *ii*) radiating divertor with impurity seeding [8], and *iii*) a quasi-snowflake (QSF) divertor configuration [9], have been applied successfully for active control of heat and particle fluxes deposited on the divertor targets in steady-state operation on EAST. LHW-induced particle and heat flux striations are also present in the H-mode plasmas, reducing the peak heat flux and erosion at the main strike point, thus facilitating long-pulse operation with a new steady-state H-mode over 60 s being newly achieved in EAST [8].

In addition, several new physics investigations, including RF induced intrinsic rotations, influence of SOL drifts on the divertor in-out asymmetry [10], and the active control of core MHD and disruption mitigation, have been performed on EAST. In this paper, an overview of recent progresses of EAST physics experiments towards high-performance steady-state H-mode operation will be presented.

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