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E_rxB shear effect on cross phase mitigates ELM at high collisionality

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A non-stationary, effective edge localized modes (ELMs) mitigation / suppression regime has been recently obtained by counter NBI heating at high collisionality on the Experimental Advanced Superconducting Tokamak (EAST). Our results show that counter NBI can significantly enhance the reversed toroidal rotation as well as the E_r×B flow shear of the pedestal. With the increased E_r×B flow shear, the ELM sizes can be suppressed by nearly 80%. The increased E_r×B flow shear can also broaden the power spectrum of the pedestal turbulence and enhance the amplitude of modes with high frequency (f>100kHz). The bispectrum study indicates that the nonlinear mode coupling of the pedestal turbulence also increases in counter NBI case, which can interrupt the linear growth of the peeling mode, thus leading to the suppression of ELM. When power of counter NBI is high enough, an ELM-free H mode can even be achieved on EAST. During the ELM-free H mode, the line averaged density as well as the amplitude of resistive ballooning mode keeps increasing until the H-L back transition. Those observations may link with the density limit in H mode discharge.
BOUT++ simulations have been applied to study the characteristics of edge-localized mode at fixed high collisionality for different E_r structure. The simulation result reveals that the increased E_r×B shear suppresses the ELM size and delays the pedestal crash, which is consistent with the observations on EAST. Analysis of the cross-phase spectrum of potential and pressure perturbations indicates that the increased E_r×B shear can shorten the phase coherence time τ_c and flatten the spectrum of τ_c, which is and limited by nonlinear mode interaction. Thus, the peeling-ballooning mode doesn't get enough time to allow growth to large amplitude, which can be supported by the bispectrum study on EAST that increased ErxB flow shear can enhance the nonlinear interaction.
Besides the collisionality, our simulations suggest a new way (Er shear) to control the ELM size, which is consistent with observed ELM suppression at larger E_r×B shear in high collisionality plasmas on EAST.

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