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Effect of density profiles on the pedestal performance

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The EPED model [1] (and other EPED-like models) has been validated on many tokamaks and has successfully predicted the pedestal structure. In the standard EPED model, the density and temperature pedestals are assumed to have the same position and width. However, under some experimental conditions, such as strong gas fueling, lithium injection and impurity seeding, the density pedestal could change its width and position, and the pressure pedestal height and ELM behavior also change. In this study, we developed the REPED model to study the effect of density profiles on the pedestal performance in EAST, and then used the model to predict the ITER pedestal performance.

EAST has some unique features that may affect the pedestal structure, such as lithium wall conditioning, LHCD dominant heating power, full metal wall and tungsten divertor. The REPED model [2], also an EPED-like model, has been validated with EAST experiments. But the pedestal width coefficient G=0.12, a little larger than the typical values in other tokamaks.

We further developed the REPED model to consider the density pedestal and the temperature pedestal to have different structures. The REPED shows that as the separatrix density increases, the pressure pedestal height increases. The reason is that the higher the separatrix density, the lower the pedestal gradient, which makes the ballooning modes more stable. Our calculation also shows that the density pedestal width can affect the pressure pedestal height. If the density pedestal width is wider than the temperature width, the pressure pedestal height could increase; while the narrower density pedestal could cause the pressure pedestal height to decrease. An EAST discharge is used to validate our model. In this discharge lithium injection made the density pedestal width wider than the temperature pedestal width, and the experimental pressure pedestal height agrees with the REPED prediction. Neon seeding could further make the density pedestal even wider and the discharge became ELM-free. In this situation, the REPED could not predict the pedestal height because the stability analysis shows that the operation point is far away from the peeling-ballooning boundary.

The model is applied to ITER to see the effect of density profiles on the ITER pedestal performance. Figure 1 shows that if the density pedestal is 0.02 wider than the temperature, the pressure pedestal height could increase by 10%.

References

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[2] K. Li et al, Plasma Phys. Control. Fusion 62, 11500 (2020)

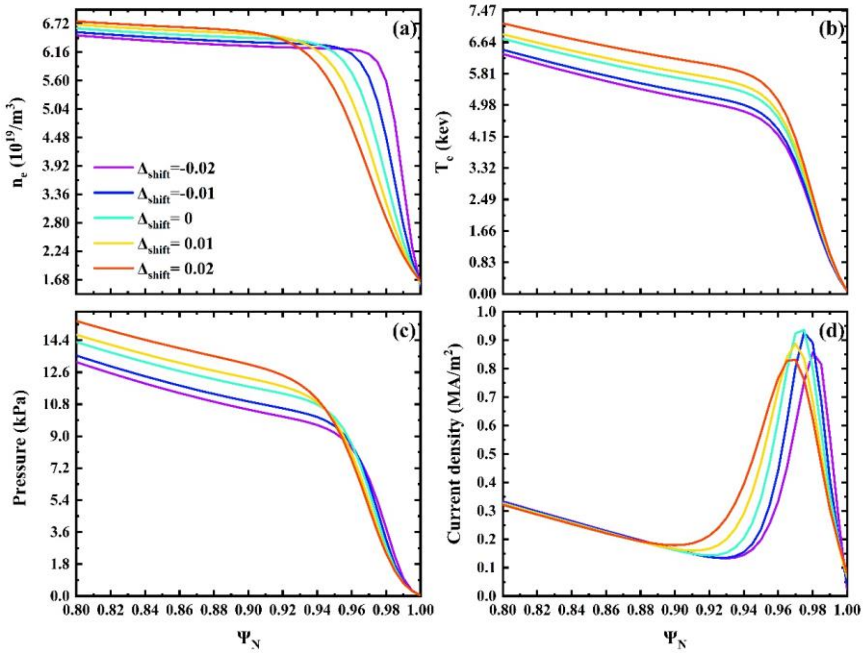

Figure 1. Predicted ITER pedestal structure with density pedestal wider or narrower than temperature. (a) Density profiles; (b) Temperature profiles; (c) Pressure profiles; (d) Current density profiles.