4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Grassy ELM regime at low pedestal collisionality in high-power tokamak plasma

Y.F. Wang[1], H.Q. Wang[2], G.S. Xu[1], G.Z. Jia[1], F. Turco[3], C.C. Petty[2], J.L. Chen[1], N. Yan[1], Q.Q. Yang[1], L. Wang[1], A.M. Garofalo[2], X.Z. Gong[1], H.Y. Guo[2] and B.N. Wan[1]
[1]Institute of Plasma Physics, Chinese Academy of Sciences,
[2]General Atomics, [3]Columbia University
e-mail (speaker): yfwang@ipp.ac.cn

Spontaneous mitigation of giant ELMs and appearance of grassy ELMs have been observed repeatedly at low pedestal collisionality ($\nu^*_{\rm e,ped}$~0.15) in the high-power ($P_{\rm inj}$>13 MW) hybrid scenario in DIII-D [Fig. 1].[1] Higher $\beta_{\rm p}$ and higher q_{95} appear to be beneficial to achieving the grassy ELM regime. The grassy ELM H-mode plasma shows high energy confinement performance (H_{98y2} up to over 1.5) under the conditions of high neutral beam torque and high core rotation.[2] The pedestal width appears to exceed the EPED1.0 model prediction by more than 50%. Pedestal stability analysis performed with the ELITE code indicates that the stability against low-*n* kink/peeling modes is improved with increased auxiliary heating power and the operational point in the grassy ELM regime is located near the ballooning boundary.[3] The pedestal stability characteristics during the grassy ELM crashes have been investigated in comparison with the giant ELM crashes based on plasma profiles experimentally measured with high resolution and accuracy. It has been found that the underlying mechanism for the observed small-amplitude ELM crashes is mainly the expansion of the ballooning stability boundary induced by an initial radially localized collapse in the pedestal, which helps to stop the growth of instabilities and further collapse of the pedestal.[4] The effect of electron density pedestal on mitigating edge localized instabilities has been analyzed by numerical simulation, suggesting that the electron density pedestal characterized by high $n_{\rm e,sep}/n_{\rm e,ped}$ and low density gradient helps to stabilize peeling-ballooning modes because of a low pressure pedestal gradient and to lower the ballooning boundary mainly because of a low ion diamagnetic frequency in the pedestal region, thus triggering ballooning instabilities and producing the intrinsic grassy ELMs. Numerical simulation of the Chinese Fusion Engineering Test Reactor (CFETR)[5] with the SOLPS code indicates that the separatrix density might be insensitive to the electron diffusivity in the pedestal region and increase with the power flowing from the core region to the edge region [Fig. 2]. Pedestal stability analysis suggests that the flat density pedestal with high separatrix density obtained in the high-power plasma in CFETR would make the operational point close to the ballooning boundary, which is considered to help destabilize ballooning instabilities and facilitate the access to the grassy ELM regime.

This work is supported by US DOE under Contract Nos. DE-FC02-04ER54698 and DE-SC0010685 and Key Research Program of Frontier Sciences, CAS, under Grant No. QYZDB-SSW-SLH001 and K C Wong Education Foundation.

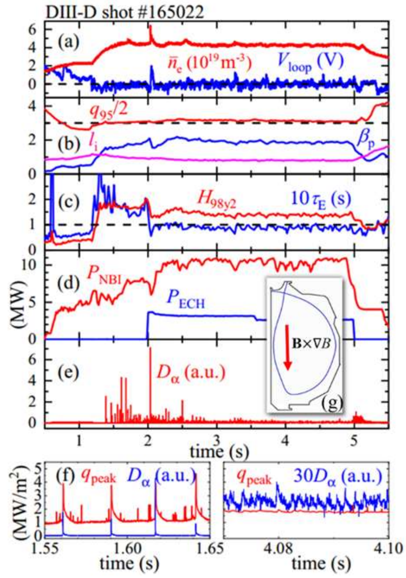

Fig. 1. Time traces for a typical stationary hybrid discharge with intrinsic grassy ELMs in DIII-D.

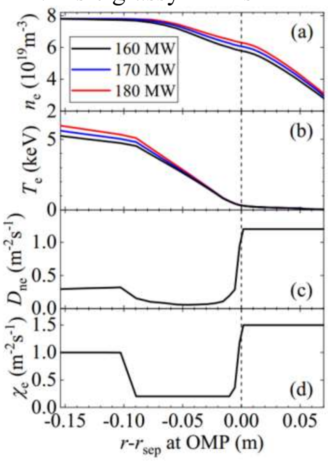

Fig. 2. Radial edge profiles of (a) electron density, (b) electron temperature, (c) electron density diffusivity and (d) electron thermal diffusivity with different input powers scanned in the SOLPS simulation of CFETR are shown.

References

[1] H.Q. Wang et al., Phys. Rev. Lett. **124**, 195002 (2020).
[2] W.M. Solomon et al., Nucl. Fusion **53**, 093033 (2013).
[3] T.W. Petrie et al., Nucl. Fusion **57**, 086004 (2017).
[4] G.S. Xu et al., Phys. Rev. Lett. **122**, 255001 (2019).
[5] G. Zhuang et al., Nucl. Fusion **59**, 112010 (2019).