MHD@Dalian Code simulation of NTM control via ECCD for disruption avoidance

Liu Tong[1], Wang Zheng-Xiong[1], Wei Lai[1] and Wang Jialei[2]
[1] Dalian University of Technology, China
[2] National Institute for Fusion Science, Japan
e-mail (speaker): liutong@dlut.edu.cn

It is well-known that neo-classical tearing mode (NTM) is very dangerous for reactor-scale tokamak devices, because it can largely limit achievable plasma beta and even lead to major disruptions. Given this potential economic loss by damaging experimental devices, the mitigation and/or active control of NTMs are of high priority for the performance in advanced devices such as ITER and future reactors. MHD@Dalian Code (MDC) [1-3] is developed as a powerful tool to deal with long time scale nonlinear simulation of NTMs and works well. Recently, the electron cyclotron current drive (ECCD) module in MDC has even been upgraded to include condensation effect [4] of ECCD. For disruption avoidance, a series of numerical researches about NTM control by ECCD have been carried out via MDC. In this work, MDC is adopted to numerically investigate the suppression of NTMs and NTM triggering explosive bursts (shown in figure 1) by ECCD in tokamak plasmas. MDC model includes both nonlinear evolving bootstrap current and EC driven current with condensation effect. It is found that the ECCD with appropriate input power and switch-on time can effectively stabilize the NTM islands and NTM triggering explosive bursts [1]. Due to the existence of strong zonal magnetic field during nonlinear evolution of NTMs, the switch-on time of ECCD should be as early as possible to obtain a better effectiveness. On the other hand, the ill-advised application of ECCD may cause unexpected explosive bursts [3]. While using ECCD to control NTMs, a threshold in EC driven current has been found. Below the threshold, not only are the NTM islands not effectively suppressed but a deleterious explosive burst could also be triggered, which might contribute to major disruption for tokamak plasmas. In order to prevent this ECCD from triggering explosive bursts, three control strategies have been attempted and two of them have been recognized to be effective. Moreover, the condensation effect of ECCD may offer additional extraordinary control effectiveness. Based on the numerical results, useful suggestions are proposed for control strategy design to better control NTMs in real tokamak experiments. The numerical results systematically reveal the basic physical process of stabilizing NTMs and the NTM-triggering explosive burst by ECCD. The proposed control strategies may be significant in the context of experimental efforts to stabilize NTM islands and may make substantial contribution to the magnetic fusion field.

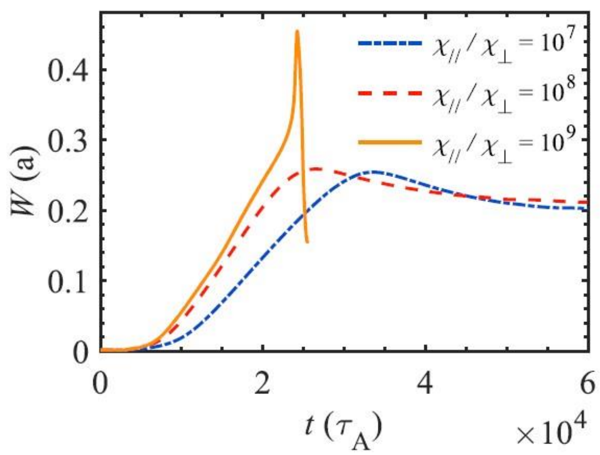

Figure 1. Temporal evolution of NTM magnetic island width under different ratio of parallel and perpendicular transport coefficients. It is noted that, with increasing the ratio, the NTM is becoming more and more unstable, and eventually lead to explosive bursts.

References

[1] Liu T. *et al* 2018 *Nucl. Fusion* **58** 076026
[2] Liu T. *et al* 2020 *Nucl. Fusion* **60** 106009
[3] Liu T. *et al* 2022 *Nucl. Fusion* **62** 056018
[4] Reiman A. H. and Fisch N. J. 2018 *Phys. Rev. Lett.* **121** 225001