19th International Workshop on H-mode Physics and Transport Barraiers, 24-27 Sep, 2024 at Mito, Ibaraki, Japan

Simulation Study on Fast Ion Loss and Heat Load on Limiters under Reversed Shear Configurations in EAST

Yifeng Zheng[1], Guoqiang Li[1], Xuexi Zhang[1], Guosheng Xu[1], Zhen Zhou[1], Baolong Hao[2], Yifeng Wang[1]

[1] Institute of Plasma Physics, Chinese Academy of Sciences, Heifei 230031, China

[2] National Institute of Physics, P. O. Box 432, Chengdu 610041, China

e-mail (speaker): yifeng.zheng@ipp.ac.cn

The key to designing high-confinement performance operation modes is to maintain an acceptable confinement performance of the fusion plasma while reducing damage to the components facing the plasma. Scenarios with weak magnetic shear or reversed-shear q-profiles exhibit better confinement performance due to the formation of internal transport barriers and a high fraction of bootstrap current, and are therefore considered promising for the design of high-confinement performance operation modes[1]. Scenarios with weak reversed shear or localized reversed-shear q-profile can be achieved through methods such as electron cyclotron resonance heating (ECRH) and neutral beam injection (NBI). Internal transport barriers effectively reduce cross-field plasma transport, thereby enhancing the confinement capability of the main plasma. However, under scenarios with reversed-shear q-profiles, the current in the plasma core is lower, leading to a weaker poloidal magnetic field in the core region, which in turn increases the orbit width of fast ions and exacerbates the loss of fast ions in the core. Additionally, compared with scenarios with normal shear q-profiles, the ripple random loss region under scenarios with reversed-shear q-profiles is larger, resulting in more severe fast ion losses due to ripple stochastic diffusion. Increasing the core current density and moderately reducing the degree of reversed shear can effectively improve the situation of fast ion losses. By adjusting the q-profile from strong reversed-shear to localized weak reversed-shear q-profile, it not only helps reduce fast ion losses but also enhances the confinement effect on the main plasma. This paper uses the full-orbit-following particle tracking program ISSDE[2-4] to track fast ion trajectories under scenarios with different reversed-shear q-profiles and to study the impact of scenarios with different shear q-profles on fast ion losses and heat load on limiters. Simulation results show that for scenarios with normal shear q-profiles, the smaller the q_{min}, the worse the confinement of the main plasma, but the better the confinement of fast ions. Both scenarios with strong reversed-shear q-profiles and localized reversed-shear q-profiles lead to increased fast ion core transport due to low core current densities, thereby increasing fast ion losses. When the q_{min} value is in the core and a localized weak reversed-shear q-profile occurs at off-axis positions, the fraction of fast ion losses will be minimized. The peak value distribution of heat loads on limiters corresponding to the share of fast ion losses under scenarios with different shear q-profiles also shows a similar pattern. Through the regulation of the current profile, not only can the main plasma be effectively confined, but fast ion losses can also be significantly reduced, which is of great value for designing high-confinement mode operations.

References

[1]X. X. Zhang *et al*, Plasma Phys. Control. Fusion **63** 065013 (2021)

[2]Y. F. Zheng *et al*, Chin. Phys. B **30** 095201 (2021)

[3]Y. F. Zheng *et al*, Chin. Phys. B **31** 075201 (2022)

[4]Y. F. Zheng *et al*, Nucl. Fusion **63** 046016 (2023)