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

Alpha particle ripple loss in CFETR steady-state scenario

Rui Zhao[1], Zheng-Xiong Wang[1], Feng Wang[1], and Baolong Hao[2,3]
[1] School of Physics, Dalian University of Technology,
[2] Advanced Energy Research Center, [3]College of Optoelectronic Engineering, Shenzhen University
e-mail (speaker): zhaorui2018@mail.dlut.edu.cn

Confinement of alpha particles is one of the key issues of burning plasma in tokamaks. Due to the discreteness of the toroidal field (TF) coils, the loss alpha particles induced by TF ripple can cause a strong heat load on the first wall. The Chinese Fusion Engineering Test Reactor (CFETR) is a bridge between ITER and the magnetic fusion energy demonstration reactor (DEMO), which will be the next device in Chinese magnetic confinement fusion program. In this work, by using the guiding center code ORBIT, we investigated alpha particle TF ripple loss in CFETR steady-state scenario (v20190422), in which both the initial distribution and classical steady-state slowing down distribution of alpha particles are considered.

Effects of TF ripple on three particle loss mechanisms, namely prompt loss, ripple trapping loss, and stochastic diffusion loss [1], are analyzed in detail. As shown in Fig. 1, the loss particle initial position in $R-Z$ coordinate with different TF ripple values δ_0 are plotted. Through comparison, it is found that the collisionless stochastic diffusion is the main mechanism of alpha particle ripple loss. With the increase of δ_0, the particles located near the core are influenced by TF ripple and the number of loss particles is increasing.

Moreover, the toroidal and poloidal profiles of the heat load on the first wall are calculated. Fig. 2 shows the total heat load distribution, where the ζ and θ represent the toroidal angle and poloidal angle, respectively. The maximum heat load is $0.189\ \mathrm{MW/m^2}$, which is below the safety threshold of CFETR. We can observe that the hot spots are localized both in toroidal direction and poloidal direction. In the toroidal direction, particles are more likely to be lost in the position between two TF coils; in the poloidal direction, particles are lost up to the middle plane $(\theta = 0)$, where the TF ripple is strong.

In addition, a comparison study of alpha particle ripple loss in the hybrid scenario (v20190422) [2] has been carried out. It is found that both total particle loss fraction and maximum heat load in the steady-state scenario are approximately 50% larger than those in the hybrid scenario.

This work was supported by the National Natural Science Foundation of China (Grant Nos. 11925501, 11975068, 11875099 and 11905142), and Liao Ning Revitalization Talents Program (Grant No. XLYC1802009).

References

[1] Wu B. *et al.* 2017 *Plasma Phys. Control. Fusion* **59** 025004.
[2] Hao B.L. *et al.* 2020 *Sci. Sin.* (*Phys. Mech. Astron.*) **50** 065201.

Figures

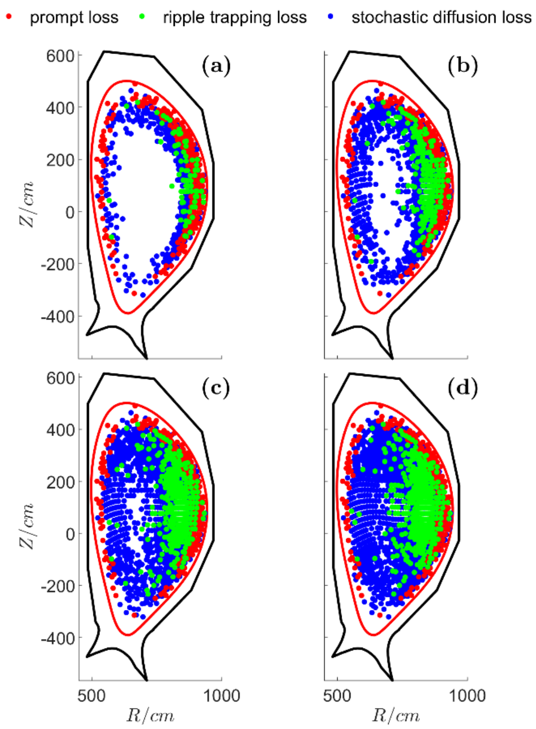

Fig. 1. The initial position of particles with different loss mechanism corresponding to the initial fusion alpha particles with the TF ripple value: (a) $\delta_0 = 1\times10^{-5}$; (b) $\delta_0 = 2\times10^{-5}$; (c) $\delta_0 = 3\times10^{-5}$; (d) $\delta_0 = 4\times10^{-5}$.

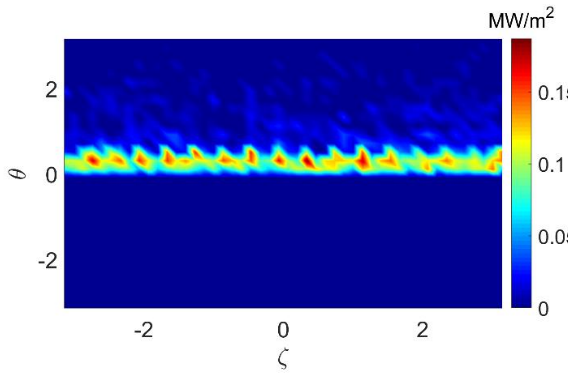

Fig. 2. The total heat load on the first wall of the CFETR steady-state scenario.