Effects of alpha particles on the transport of helium ash driven by collisionless trapped electron mode turbulence

Guangting Zhu[1], Weixin Guo [1], Lu Wang[1]

[1] *Huazhong University of Science and Technology, Wuhan, China*

The effects of alpha (α) particles on the removal of helium ash driven by collisionless trapped electron mode (CTEM) turbulence are analytically studied by means of quasi-linear theory. Under the parameters used in this work, the removal of helium ash is mainly determined by diffusivity due to much weaker impurity convective velocity. Through analyzing the parametric dependence of the ratio between helium ash diffusivity and the effective electron thermal conductivity (i.e., D_{He}/χ_{eff}), it is found that although $D_{He}/\chi_{eff} < 1$, which is less efficient for the removal of helium ash as compared with ion temperature gradient (ITG) mode [1], D_{He}/χ_{eff} can be increased 50% by the presence of 3% α particles with their density gradient being twice that of electrons. This is mainly because the destabilizing effect of α particles [2] on helium ash diffusivity is stronger than that on electron thermal conductivity. Moreover, the higher concentration as well as the steeper profile of α particles, the stronger enhancement of D_{He}/χ_{eff} . Meanwhile, α particles do not qualitatively change the parametric dependence of D_{He}/χ_{eff} on the electron temperature and the fraction of tritium (T) ions. Finally, it is also found that both the diffusivities of deuterium (D) and T ions are still smaller than that of helium ash even with α particles, which is similar to the case without α particles [3]. These results might be favourable for more accurate prediction of helium ash profile and efficient removal of helium ash in the fusion reactor burning plasmas.

Key words: alpha particles, removal of helium ash, CTEM, D_{He}/χ_{eff}

Reference:

[1] C Angioni, A G Peeters et al. Gyrokinetic simulations of impurity, He ash and α particle transport and consequences on ITER transport modelling. Nuclear Fusion, (2009). 49: 055013.

[2] M S Hussain, Weixin Guo, Lu Wang. Effects of energetic particles on the density-gradient-driven collisionless trapped electron mode instability in tokamak plasmas. Plasma Physics and Controlled Fusion, (2021). 63: 075010.

[3] Weixin Guo, Mingzhu Zhang, Lu Wang, Ge Zhuang. The role of collisionless trapped electron mode turbulence on removal of helium ash and transport of deuterium-tritium ions. Nuclear Fusion, (2020). 61: 016020.