9^{th} Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Comprehensive study of the transport and kinetic source of helium ash from alpha particles

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Future deuterium-tritium (D-T) burning plasmas will generate energetic alpha (α) particles with the birth energy 3.5 MeV. When the energy of α particles is decreased to be comparable with the temperature of background plasmas, they are referred as helium (He) ash. We have studied the transport of He ash [1, 2], considered the effects of α particles on drift wave-zonal flow system [3, 4] and the He ash transport [5]. Recently, we also calculate the kinetic source of He ash by including energy diffusion term, and the density profile of He ash n_{ash} by balancing source and transport is further predicted [6].

In detail, we firstly find the efficiency of He ash removal, which is evaluated by ratio between He ash diffusivity and effective electron thermal conductivity (D_{He} / χ_{eff}), is increased 55% by the presence of 3% α particles with their density gradient being twice to that of electrons, and this enhancement can be further strengthened by steeper profile of α particles. Then, by solving the Fokker-Planck equation including the energy diffusion term, we find the distribution function of He ions in the low energy region is significantly higher than the classical slowing down distribution function. This will *indirectly* increase the source of He ash. Moreover, the energy diffusion effects also introduce an additional term to the kinetic source, and it *directly* reduces the kinetic source, since the energy diffusion makes He ions diffuse from the low energy to high energy and plays a role of sink for He ash. Finally, total kinetic source is raised and the corresponding n_{ash} is also higher, as compared to the case without energy diffusion. This indicates that ignoring energy diffusion effect on kinetic source will underestimate n_{ash}.

These studies address an important topic for future burning plasmas, aid in understanding the He ash removal and predicting the n_{ash} profile in ITER.

References

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