Turbulent transport in multi-ion mixture plasmas

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Burning plasmas are intrinsically composed of multiple ion species such as Deuterium(D) and Tritium(T), the high-energy α particles produced by the fusion reaction, the thermalized Helium(He)-ash, and high-Z impurities resulting from the plasma-facing materials. More complex turbulent transport processes are, thus, expected in the burning plasmas, compared to those in the single or very few ion-species plasmas, which are usually addressed in experiments. Particularly, the optimal flux balance in the particle and thermal transport to sustain the steady burning state is remained to be unrevealed.

In this talk, recent progress (e.g., Refs. [1,2]) in gyrokinetic studies on ion temperature gradient (ITG) and trapped electron modes (TEM) driven turbulent transport in multi-ion mixture plasmas is presented, including some overview of isotope ion mass effects (e.g., Refs. 3, 4]). Particularly, a multi-species gyrokinetic Vlasov simulation with Deuterium(D), Tritium(T), Helium(He), and real-mass kinetic electrons including their inter-species collisions[Fig.1] demonstrates gyrokinetic-simulation-based analyses of a steady burning condition with He-ash exhaust and D-T fuel inward transport, which is known as Reiter's steady burning condition[5]. It is also revealed that a significant imbalance appears in the turbulent particle flux for the fuel ions of D and T, depending on the background D-T density ratio and the He-ash accumulation rate[2].

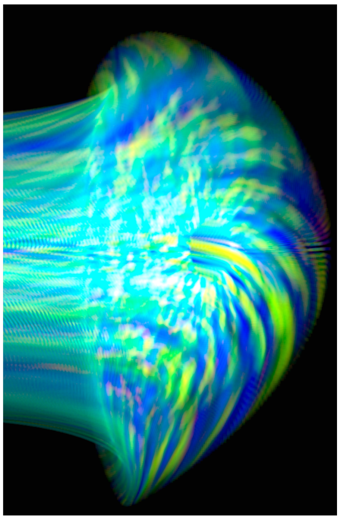

Fig. 1 Turbulence in D-T-He plasma: fluctuation is displayed by luminosity for D(blue), T(yellow), He-ash(red).

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