Model collision operators for multiple ion species plasmas and gyrokinetic entropy balance equations

H. Sugama[1,2], T.-H. Watanabe[1,2], and M. Nunami[1]

[1] *National Institute for Fusion Science, Toki 509-5292, Japan*
[2] *The Graduate University for Advanced Studies, Toki 509-5292, Japan*

sugama@nifs.ac.jp

Linearized model collision operators for multiple ion species plasmas are presented, which conserve particles, momentum, and energy, and satisfy adjointness relations and Boltzmann's H-theorem even for collisions between different particle species with unequal temperatures. The model collision operators are also written in the gyrophase-averaged form that can be applied to the gyrokinetic equation. Balance equations for the turbulent entropy density, the energy of electromagnetic fluctuations, the turbulent transport fluxes of particle and heat, and the collisional dissipation are derived from the gyrokinetic equation including the collision term and the Maxwell equations. It is shown that, in the steady turbulence, part of the entropy produced by the turbulent transport fluxes produced in the unstable nonzonal-mode region is nonlinearly transferred into the stable zonal-mode region where the collisional dissipation occurs.