Gyrokinetic simulation of ITG turbulence with slowing-down distribution of α particles

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Abstract

δf gyrokinetic codes often hardcode the Maxwellian distribution as the equilibrium distribution for all species involved in the simulations, mainly because of the difficulties in handling the polarization density for distributions other than Maxwellian. Alpha particles often take the slowing-down distribution, which usually significantly deviates from the Maxwellian one. An example is shown in Fig. 1, which shows the Maxwellian underestimates the particle number in the high energy region while overestimates it in the low energy region.

For some gyrokinetic codes, it is nontrivial to switch from a Maxwellian distribution to a slowing-down one because the analytical form of the polarization density used has assumed the Maxwellian distribution, and the numerical method used in solving the gyrokinetic Poisson equation critically relies on the particular analytical form.

In this talk, I will introduce a new gyrokinetic code, `TEK`, which is developed with α particles in mind, and thus can handle the slowing-down distribution accurately. I will present electrostatic ITG turbulence simulations including α particles and kinetic electrons in the CFETR reactor. Electromagnetic simulations will also be presented if I can make the electromagnetic version work before the meeting.

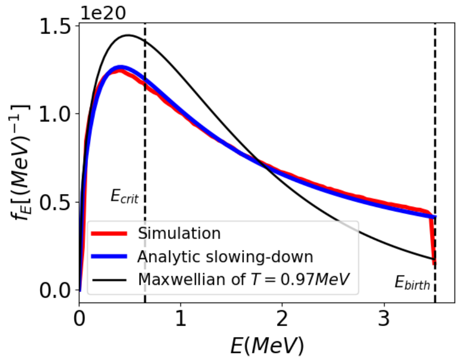

Figure 1. Comparison between neoclassical simulation, analytical slowing-down, and Maxwellian distribution in CFETR. The critical energy E_{crit} and birth energy E_{birth} are indicated in the figure, where $E_{\mathrm{crit}} = 0.65\mathrm{MeV}$ is the radially averaged value among all the markers. The results show that Maxwellian distribution underestimates the particle number in the high-energy region ($E > 2\mathrm{MeV}$) while overestimates the number in the low-energy region.