Anisotropic analytical and numerical distribution functions in the global gyrokinetic particle-in-cell code ORB5

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Most systems simulated with gyrokinetic codes assume that the species are close to Maxwellian. While this is often sufficient for the bulk ions and bulk electrons, it is insufficient to describe in particular energetic particles (EPs), e.g. alpha particles (slowing down, isotropic), NBI particles (slowing down, anisotropic), or ICRH-accelerated particles (anisotropic).

In this presentation, we discuss the extension of the global electromagnetic gyrokinetic particle-in-cell code ORB5 [1] to take arbitrary background distribution functions into account. Previous work with ORB5 used Maxwellian distribution functions for turbulence and Alfvén eigenmode physics, in which the radial density and/or temperature gradients are sufficient for mode excitation; or it used a simplified bump-on-tail distribution function for physics studies in which velocity gradients are required for mode excitation (e.g. EP driven Geodesic Acoustic Modes (EGAMs)). Recent work had also extended ORB5 to include isotropic slowing down distributions [2], for example for alpha particle distributions.

Quantitative predictions of EGAMs in experiments require a more realistic distribution function, as do quantitative predictions of NBI-driven Alfvén eigenmodes. We report on how ORB5 was generalized to handle arbitrary distribution functions, how an analytical anisotropic slowing down distribution function was implemented, and how output from the NBI solver RABBIT [3] was coupled to ORB5 as a way of modelling realistic experiment NBI distribution functions.

Finally, we discuss a subtlety in dealing with distribution functions which might not be a priori consistent equilibrium distribution functions.

References

[1] E. Lanti et al., Comput. Phys. Commun., 251 (2020)

[2] F. Vannini et al., 47th EPS Conference on Plasma Physics (2021)

[3] M. Weiland et al., Nucl. Fusion, 58(8) (2018)