Distribution functions in gyrokinetic PIC codes: δf & f_0 and full-f: ORB5 and PICLS

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Abstract

We discuss two gyrokinetic particle-in-cell (PIC) codes, ORB5 [1] and PICLS [2]. ORB5 is a core-focussed electromagnetic δf code, used extensively for energetic particle (EP) physics. EPs are present in tokamaks from sources such as Neutral Beam Injection, Ion Cyclotron Resonance Heating, or alpha particles from fusion reactions. Since EP distributions in tokamaks are weakly collisional and are often far from Maxwellian distributions, and in many cases highly anisotropic. We discuss the implementation of various analytical, semi-analytical, and fully-numerical distribution functions (f_0) in ORB5. This leads to some particular care which must be taken when considering a static equilibrium, especially important when wanting to perform linear simulations.

A related topic is one of representing the distribution function in Constants-of-Motion (COMs) [3], a diagnostic based on which can be used to evaluate the so-called Phase Space Zonal Structure (PSZS) [4], where the PSZS can be related to nonlinear equilibria, EP transport, and construction of consistent reduced models,

We outline how this diagnostic could be inverted, and how a numerical distribution function could be represented in COMs in the future, or how PSZSs could be used as a representation to pass distribution functions between models for integrated modelling.

Finally, we talk about the full-f gyroinetic PIC code PICLS, developed for the tokamak edge, in where there is no separation between a background distribution function and a fluctuating part of the distribution function. This code has recently been extended from 1D to 3D, and we mention the validation of the 3D (2D+1D) solver.

References

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