Microinstability simulations for stellarators involving kinetic electrons and realistic profiles with the global PIC code EUTERPE

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EUTERPE is a global (full radius, full flux surface) gyrokinetic particle-in-cell (PIC) code particularly suited to simulate plasmas in 3D magnetic field configurations. Capable of dealing with up to three kinetic species (ions, electrons and fast particles) it is our standard tool to study the formation and evolution of microinstabilities in fusion devices like the Wendelstein 7-X (W7-X) stellarator. The code can be operated in both electrostatic as well as electrodynamic regime and take into account effects of nonlinearity.

In order to support the analysis and understanding of findings from the first operational campaigns and in preparation of upcoming experiments, there is an urgent need for numerical simulation of microinstabilities which rely on kinetic models of all particle species involved and with realistic assumptions about their mass ratios as well as the thermodynamic parameters and profiles.

Modelling fusion plasmas with both kinetic ions and electrons opens the way for studying the wide spectrum of different instabilities and their interactions predicted by theory and observed in experiments (ITG, TEM, ETG, ...). But it also makes the numerical task much more challenging than the problem of ion-temperature-gradient (ITG) driven instabilities with adiabatic electrons studied earlier [1, 2]. The large ion-electron mass ratio requires much smaller time steps and leads to very long run times, slowing down the process of testing and actual simulation significantly. In order to gain accuracy, a suffiently large number of test particles and an adequate amount of memory is required. Finally, aiming at the use of realistic parameters leads to fairly high mode numbers which in turn require an adequate spatial resolution which can easily lead to the capacity limits of the involved numerical tools and computing platforms. It is therefore a challenging task to perform this kind of simulations with acceptable effort.

References

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