§14. Simulations of Electron Bernstein Waves, Linear ITG Instabilities and Zonal Flows in Helical Systems

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1) Simulation of EBWs in Helical Systems

Due to their electrostatic nature, Electron Bernstein Waves (EBWs) do not experience any density limit. This makes them particularly useful to interact with over-dense plasmas. However, the 'over-dense' condition is not only reached due to a very high plasma density. Propagation cutoffs depend also on the frequency of the wave and the local magnetic field and are common in magnetic confinement devices. This is why EBWs are presently a popular subject both in the tokamak and helical communities for their ability to overcome the density limits and deposit power in otherwise inaccessible regions of the plasma. The study of EBW and their applications has been recently a matter of interest in Japanese helical devices. Experimental campaigns involving research on EBW have been carried out in the LHD and CHS experiments in NIFS as well as the Heliotron-J in Kyoto University. In order to contrast these experimental results with the theory and to devise new experiments, numerical simulations of ray tracing, mode conversion and power deposition of EBW have been setup. These simulations are performed with the aid of the ART ray-tracing code. A first set of calculations of over-dense scenarios in CHS has been performed and a new set of simulations for low field and low density scenarios is in progress. A collaboration with the Heliotron-J group in Kyoto University is currently working on the implementation of the ART and COBE codes to model Heliotron-J EBW and current drive experiments. A benchmark with existing codes, such as the TRAVIS code, is expected with respect to simulations on the LHD device.

2) Gyrokinetic simulation of ITG modes and zonal-flow evolution in multiple-helicity helical fields

The standard and inward shifted configuration of LHD have been modeled via the inclusion of multiple helicity Fourier expansion terms in the description of the magnetic field geometry. Linear gyrokinetic Vlasov simulations with the GKV code have been performed in order to study the effects of these terms on Zonal Flows (ZF) and Ion Temperature Gradient (ITG) instabilities. Simple and realistic models for the standard and inward-shifted configurations have been used in order to assess the relevance of an accurate description of the experimental scenarios and to identify the parameters that have a greater impact on ZF evolution and ITG modes.

As presented in Fig. 1, simulation results show a greater life-time of the ZF in the inward-shifted cases which has been verified to be linked to the slower radial drift velocity of helically trapped particles via velocity space studies of the perturbed ion distribution function. The longer ZF life-time of the inward shifted configuration together with an ITG instability growth rate level similar to that of the standard case suggests a more efficient regulation of the Anomalous Transport (AT) in the former one, as observed in the experiment. These results are in agreement with the conjecture that the neoclassical optimization achieved in the inward-shifted configuration contributes to the reduction of the AT by enhancing the ZF life-time. Moreover, comparison between theoretical predictions and simulation results have helped to identify those parameters that have a greater impact on the ZF life-time, such as the aspect ratio and the safety factor, in addition to the multiple-helicity field components.

These calculations have served also to select the model configurations to be used as starting point in non-linear gyrokinetic simulations.

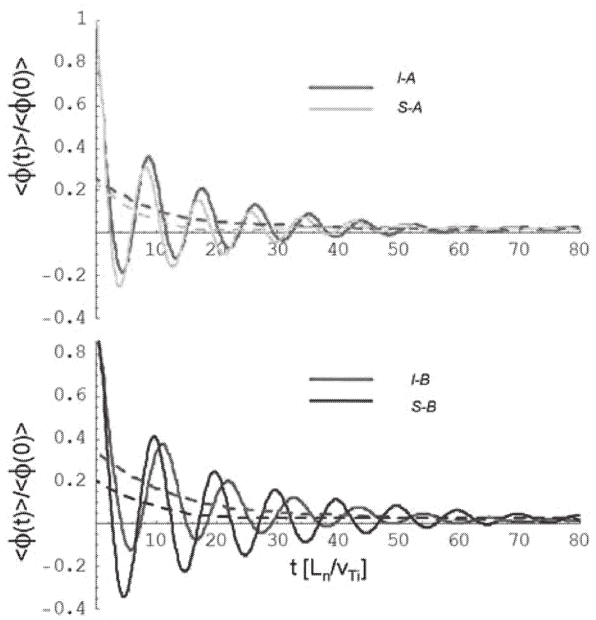

Figure 1: ZF evolution for the standard and inward-shifted configurations of LHD using simple (S-A/I-A, top figure) and realistic (S-B/I-B, bottom figure) model implementations.