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

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Simulation of EBWs in helical systems

Helical devices with their complicated geometry offer a wide range of possibilities for mode conversion and power deposition. Ray tracing simulations for different mode-conversion scenarios leading to Bernstein wave heating in helical systems have been performed [1] by means of the ART code. OXB and XB simulations in CHS have been shown to be in agreement with experimental results. The OXB ray tracing calculations show a clear OXB conversion that justified the power deposition beyond the O-mode cutoff point. The XB simulations, show successful conversion when the ray is directed towards the fundamental resonance stripe on the outer boundary and show that the power deposition region tends towards the core as the horizontal angle is widened. In this last case more calculations are on the way for greater horizontal and vertical angles to better model the experimental results shown in ref.[2]. In the Heliotron-J case, the launching point for the simulation has been imposed a few centimeters inwards from the inner boundary of the plasma in the corner region in order to model the trajectory of rays reflected on the vacuum vessel in the inner part of the torus after being injected from the outer region port. Vertical and horizontal angular scans have been carried out with the ART code obtaining XB conversion in many cases. The deposition profiles show that the energy absorbed from these rays is deposited mainly in the core region in agreement with experimental measurements.

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

The inward sift of the magnetic axis is known to improve the Neoclassical Transport (NT) in the LHD experiment in NIFS. This shift, however, is known to be responsible of the increase of the Ion Temperature Gradient (ITG) instability, which is a trigger of Anomalous Transport (AT). However, a set of experiments in NIFS showed that when shifting the magnetic axis inward, not only the NT was improved but also the confinement. The link between these two effects was thought to be the Zonal Flow (ZF). Sugama and Watanabe developed a theory which proposed that improvement of the NT meant a slower drift of the helically trapped particles that produced a higher ZF level. The key issue was to investigate the balance between the triggering effect to the AT produced by higher ITG instability and the turbulence compensation achieved through the enhancement of the ZF, in helical systems. A first set of calculations with the GKV code using a simplified geometric model for the inward-shifted scenarios already showed the link between slower drift of helically trapped particles and improvement of the ZF. More recently, linear calculations with the linear version of the GKV code have been able to show that a more accurate description of the magnetic configuration could explain the improvement of the confinement. Comparing accurate descriptions of inwardshifted and non-shifted axis scenarios, a smaller difference in ITG growth rates was observed while the ZF level in the inward-shifted case was larger than that of the non-shifted case [3]. In Fig.1, the velocity space structures of the distribution function generated in the non-shifted and the inward-shifted axis descriptions (the latter with higher ZF than the former) show the connection between slow drift of helically trapped particles and ZF. The right hand side picture corresponds to the inward shifted scenario, with higher ZF level, while in the left hand side picture, the non-shifted case shows a oscillatory distribution with a bump (red) and a hollow (blue) in the region of helically trapped particles due to their faster radial drift velocities, which leads to smaller ZF. Lately, non-linear calculations of the appropriate numerical models identified through the linear calculations have shown the turbulence compensation due to higher ZF level in the inward shifted case also at nonlinear level [4].

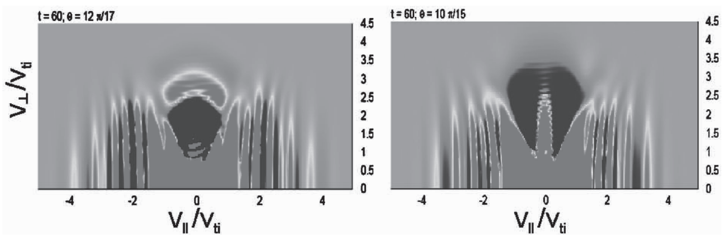

Fig.1. Velocity space structures for the same time step in the non-shifted (left) and the inward shifted (right) configurations of LHD.

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2) Y. Yoshimura *et al.*, Fusion Science and Technology **52**, 216 (2007).
3) S. Ferrando-Margalet, H. Sugama, and T.-H. Watanabe, Phys. Plasmas **14**, 122505 (2007).
4) T.-H. Watanabe, H. Sugama, and S. Ferrando-Margalet, Phys. Rev. Lett. **100**, 195002 (2008).