§7. Electrostatic Drift Waves in an LHD Configuration and a Comparable Aspect Ratio Tokamak

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The drift wave instabilities are well-known to cause the anomalous transport. They are driven by the temperature and density gradient. Thus these profiles affect the results strongly. While it may be less important, the difference of magnetic configurations can also affect the results through the local perpendicular wavelength $|k_\perp|$ and magnetic curvature. A helical device, LHD is a typical heliotron, and it has a large helical component comparable to a toroidal component of magnetic field spectrum. Thus the helical ripple effects are expected to be large. In order to investigate these local magnetic field effects on the growth rate and real frequencies of linear electrostatic drift waves, we solve the gyrokinetic-Poisson mode equation [1]. The model MHD equilibria for LHD(R_0=3.75m) and a tokamak are obtained by VMEC code, so they satisfy the MHD force balance within a numerical tolerance. For comparison with a tokamak, we should consider a one with the comparable aspect ratio, because a toroidal magnetic field is approximately proportional to it.

To eliminate the difference of flux surface quantities, we take the same value of the temperature, the density and the safety factor for LHD and the tokamak. The temperature and the density are assumed as $T/T(0)=1-s$ and $n/n(0)=(1-s)^{0.2}$ where s is normalized toroidal flux. The safety factor is chosen such as one that is obtained for an currentless LHD with above T and n profiles. Thus the shear dq/dr is negative for both cases.

In Fig.1, we show the ITG and TEM frequencies as a function of $k_\theta \rho_{thi}$ in the LHD configuration. It can be seen that the ITG with negative real frequency is stabilizing with increasing $k_\theta \rho_{thi}$ while TEM with positive real frequency is not. This is typical in the wavelength region where the ion FLR effects are impotant.

Next we compare the radial and $k_\theta \rho_{thi}$ dependence of the ITG frequencies for the LHD and the tokamak. Here the toroidal mode number is fixed to n_k=86 for LHD and n_k=142 for the tokamak such that the $k_\theta \rho_{thi}$ for both configurations is almost the same in the radial direction, which is shown in the right Y-axis (dotted lines) in Fig.2. The eigenfrequencies in the core are not so different for both configurations. This indicates that the frequencies are almost determined by the $k_\theta \rho_{thi}$ value and the local curvature or perpendicular wave length have small effects. The difference becomes large in the edge, which may be due to the helical bad curvature. Then the stabilization in the core is considered to be due to the ion FLR effect of high $k_\theta \rho_{thi}$, The mode is also stabilized in the very near edge, which is due to small $k_\theta \rho_{thi}$.

In Fig.3, the TEM frequencies in LHD are shown. In the tokamak case, the TEM was stable which may be explained by the drift reversal due to the negative dq/dr [2]. In the LHD case, the large fraction of electrons can be trapped in the helical ripples, and the TEM can be unstable. The mode is stabilized in the core, but it cannot be explained by the ion FLR, as can be seen in Fig.1. Thus this can be considered to be due to the smallness of helical ripple well.

We compare the ITG and TEM in an LHD and an tokamak configurations where T,n,q are taken to be the same. The ITG can be found in both but the TEM can be unstable only in the LHD. The resemblance of ITG nature may be due to the negative shear assumed here. The minor difference of growth rate should be due to helical ripples.

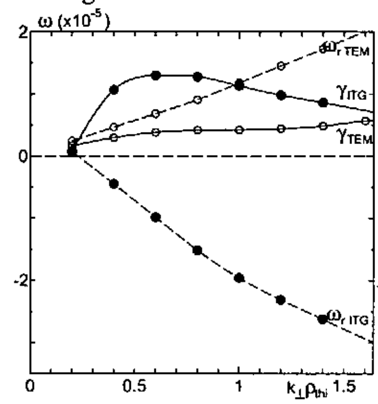

Fig. 1. $k_\theta \rho_{thi}$ dependence of ITG(closed circles) and TEM(open circles).

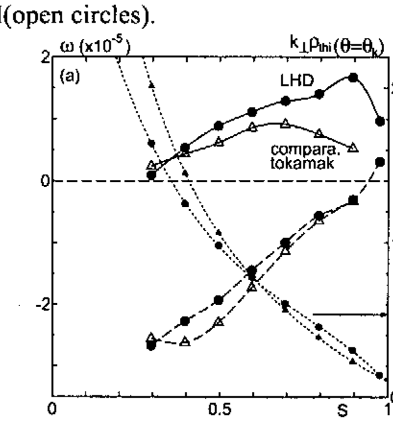

Fig. 2. Radial dependence of ITG frequencies.

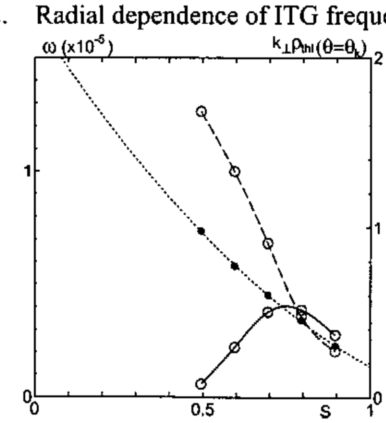

Fig. 3. Radial dependence of TEM frequencies.

Reference

[1] Rewoldt. G., et. al., Phys. Fluids **25**, (1982) 480

[2]Yokoyama. M., et. al., Nucl. Fusion **42**, (2002) 1094