Probing the linear structure of toroidal drift modes.

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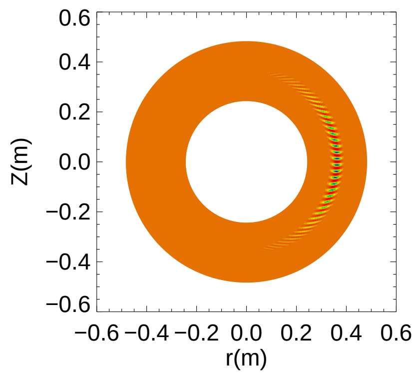
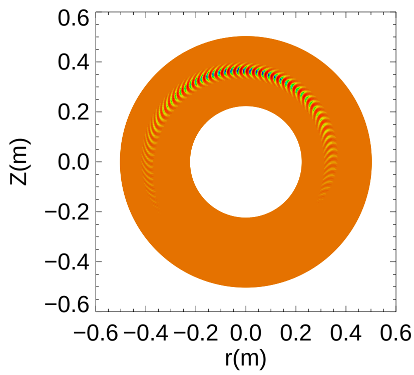
High resolution computational studies of the nature of high toroidal mode number, n, 2D linear toroidal drift modes are compared with predictions from a local ballooning theory. The focus is on the ion temperature gradient (ITG) eigenmode problem for modes with finite n, in a simple tokamak geometry with arbitrary profiles. The infinite n 1D local ballooning problem is also solved to derive the local complex mode frequency, $\Omega_0(x, k)$ for any complex value of the ballooning angle k at the radial position x.

For *isolated* modes, occurring at turning points in Ω_0, there is good agreement between the 2D results and the 1D ballooning prediction, with the mode localised on the outboard midplane (i.e. $\theta = 0$, where the local growth rate is largest). *General* modes, occurring away from turning points, however, are found to peak about $\theta = \pi/2$ and therefore have reduced growth rate. There is good agreement between the growth rate from the 2D code and the 1D ballooning result with $k = \pi/2$. The relative phases of the Fourier modes that couple to produce the 2D ballooning mode demonstrate a narrow spread of k about $\pi/2$ as expected from analytic ballooning theory [1].



(a) Example *isolated* mode structure



(b) Example *general* mode structure

Figure 1: Contours in the poloidal plane of electrostatic potential for an *isolated* mode and a *general* mode

A linear flow profile has been introduced into the 2D problem through a radially dependent Doppler shift to the mode frequency. The growth rates of *isolated* modes are reduced relative to the cases without flow. This is consistent with the analytic result [2], that one should take the average of the 1D result, Ω_0, over one period of k. However the poloidal extent of the mode structure need not be close to 2π. *General* modes are found to only be weakly affected by linear flow shear; k remains centred on $\pi/2$ and the growth rate of the mode does not change although the radial and poloidal extent varies.

A key conclusion is that the proper choice of k is crucial in the use of local ballooning theory (or, equivalently, flux tube approaches) to study linear eigenmode stability. The importance for non-linear investigations remains an area of further work.

References

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This work was funded partly by the RCUK Energy Programme under grant EP/I501045 and the European Communities under the contract of Association between EURATOM and CCFE.